(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 234 556 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.08.2002 Bulletin 2002/35

(51) Int Cl.[7]: **A61F 2/36**

(21) Application number: **02250525.9**

(22) Date of filing: **25.01.2002**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **23.02.2001 US 792500**

(71) Applicant: **ZIMMER INC.**
Warsaw, Indiana 46580 (US)

(72) Inventors:
- **Meulink, Steven L.**
  Warsaw, Indiana 46580-8118 (US)
- **Jennings, Jack D.**
  Warsaw, Indiana 46582 (US)
- **Crumley, James L., II**
  Fort Wayne, Indiana 46825 (US)
- **Gilliland, Tracy R.**
  Pierceton, Indiana 46562 (US)

(74) Representative: **Mays, Julie**
Barker Brettell,
10-12 Priests Bridge
London SW15 5JE (GB)

(54) Femoral stem with strengthening rib

(57) The present invention provides an improved prosthetic stem (20) for implantation in a bone. Specifically, the present invention provides a prosthetic femoral stem (20) having a strengthening rib (40) protruding from the substrate (26) thereof and being flush with a porous coating (28) formed thereon. The strengthening rib (40) is advantageously positioned so as to increase the cross-sectional moment of inertia of the prosthetic femoral stem (20) and thereby decrease the stress on the anterio-lateral surface of the femoral stem (20). A protrusion (40) in accordance with the present invention may also be utilized with a prosthetic femoral stem (20) absent a porous coating. In such an embodiment, the height of the protrusion (40) is such that the protrusion will be surrounded by the cement mantle formed when the prosthetic femoral component (20) is cemented in a femoral canal.

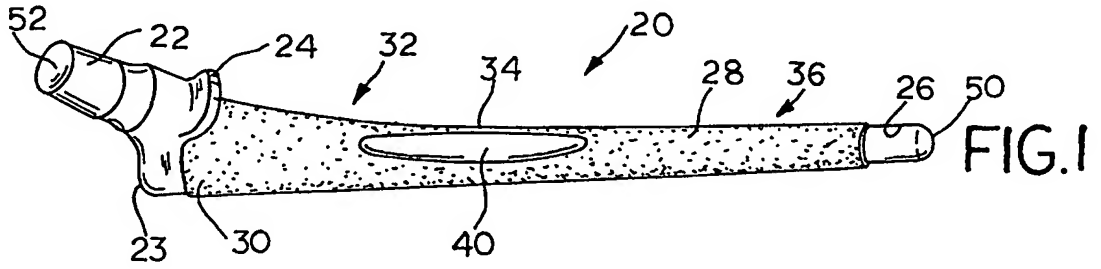


FIG.1

EP 1 234 556 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0001] The present invention relates to a prosthetic stem for implantation in a bone. More particularly, the present invention relates to a prosthetic hip stem (i.e., femoral stem) having a strengthening rib to increase the fatigue strength of the prosthetic stem.

2. Description of the related art.

[0002] Orthopedic implants utilized to replace all, or a portion of, a patient's joint (e.g., the hip) are commonly utilized to restore the use of, or increase the use of a joint which has deteriorated due to, e.g., aging, illness or injury. In the case of hip replacement, femoral components are utilized to replace a portion of the patient's femur including, e.g., the femoral head and neck. A femoral stem is positioned within a canal of the femur and is secured thereto. The femoral stem includes a femoral neck adapted to receive a prosthetic femoral head to complete the femoral prosthesis. Prosthetic femoral stems are generally either cemented in the femoral canal or are interference fit therein.

[0003] Femoral stems may advantageously include a porous external surface to accommodate bone ingrowth or cement interdigitation. Various porous substances are utilized to coat the substantially nonporous outer surface (i.e., substrate) of a femoral stem including, e. g., wire mesh, or beaded or dimpled surfaces. For the purposes of this document, "substantially nonporous" signifies a material having less porosity relative to the porous coating of a prosthetic stem.

[0004] Femoral stems are susceptible to fatigue failure after repeated loading over time. Stems having a porous coating are generally not as strong as a similarly sized stem absent a porous coating since, e.g., the substantially nonporous core of a coated stem (which is stronger than the porous coating) is smaller than the substantially nonporous core of a similarly sized stem absent porous coating. Furthermore, the porous coating of a femoral stem creates sharp corners between the porous coating and the substrate of the femoral stem. These sharp corners cause stress risers which can weaken the stem.

[0005] What is needed in the art is a femoral stem having a structure which increases the fatigue strength of a femoral stem having a porous coating without increasing the external dimensions thereof.

SUMMARY OF THE INVENTION

[0006] The present invention provides an improved prosthetic stem for implantation in a bone. Specifically, the present invention provides a prosthetic femoral stem having a strengthening rib protruding from the substrate thereof and being flush with any porous substance formed thereon. The strengthening rib is advantageously positioned so as to increase the cross-sectional moment of inertia of the prosthetic femoral stem and thereby increase the fatigue strength of the prosthetic femoral stem. The strengthening rib of the current invention increases the fatigue strength of the femoral stem not only by increasing the effective core area at a critical area of the stem (i.e., a high stress area where fatigue failure is likely to occur), but also by decreasing the stress risers associated with a porous coating at the aforementioned critical area. The strengthening rib is formed from a substantially nonporous material, and, in one exemplary embodiment is formed from a material substantially identical to the substrate material.

[0007] The invention, in one form thereof, comprises a prosthetic stem for implantation in a bone. The prosthetic stem of this form of the current invention includes a neck connected to a shaft, with the neck and shaft forming an obtuse angle. A porous substance protrudes outwardly from a substrate of the prosthetic stem and a substantially nonporous protrusion also protrudes outwardly from the substrate. The substantially nonporous protrusion is substantially flush with the porous substance so that the nonporous protrusion does not increase the external dimensions of the prosthetic stem.

[0008] The invention, in another form thereof, comprises a prosthetic hip stem for implantation in a femur utilizing bone cement to form a mantle about the portion of the hip stem inserted into the canal in the femur. The hip stem of this form of the current invention includes a neck connected to a shaft, with the neck extending from a medial side of the hip stem to form an obtuse angle with the shaft. A transition section is positioned intermediate the neck and the shaft and has a transverse cross-sectional area larger than the transverse cross-sectional area of the shaft. A protrusion is positioned on the external surface of the hip stem and has a height whereby the protrusion is covered by the mantle of bone cement when the prosthetic hip stem is implanted in a femur.

[0009] The present invention advantageously increases the fatigue strength of a prosthetic femoral stem without increasing the external dimensions thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The above-mentioned and other features and objects of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a perspective view of a femoral stem in accordance with the present invention;
Figure 2 is a side view thereof;

Figure 3 is a side view of a second embodiment of a femoral stem in accordance with the present invention;

Figure 4 is a medial view of a third embodiment of a femoral stem in accordance with the present invention

Figure 5 is a lateral view of the femoral stem illustrated in Figure 4;

Figure 6 is a cross-sectional view thereof;

Figure 7 is a cross-sectional view of a fourth embodiment of a femoral stem in accordance with the present invention;

Figure 8 is a cross-sectional view of the prosthetic femoral stem illustrated in Figure 2;

Figure 9 is a cross-sectional view of the prosthetic femoral stem illustrated in Figure 3; and

Figure 10 is a side view of a fifth embodiment of a prosthetic femoral stem in accordance with the present invention.

[0011] Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of the present invention, the drawings are not necessarily to scale and certain features may be exaggerated to better illustrate and explain the invention. The exemplifications set out herein illustrate exemplary embodiments of the invention only, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Referring now to the drawings and particularly to Figure 1, there is illustrated femoral stem 20 having porous substance 28 affixed to substrate 26 and protrusion 40 extending from substrate 26. As illustrated in Figures 2 and 8, protrusion 40 is flush with porous substance 28. The larger effective transverse cross-sectional area of substrate 26 created by protrusion 40 increases the transverse cross-sectional moment of inertia of femoral stem 20 and thereby effects a decrease in stress on the anterio-lateral surface of femoral stem 20. For the purpose of this document, "transverse cross-sectional area" denotes the area of a cross-section taken along a plane substantially perpendicular to the longitudinal axis of femoral shaft 26. Femoral stem 20 generally includes distal end 50, femoral shaft 36, transition section 30 (having medial curve 32), flange 24, shoulder 23, and neck 22 terminating in proximal end 52. The geometry of femoral stem 20 is illustrated by way of example only. It is contemplated that the teachings of the present invention will have applicability to femoral stems of varying geometry.

[0013] In the exemplary embodiment of Figures 1, 2, and 8, protrusion 40 of femoral stem 20 has a generally oval shape to maximize the coverage of porous substance 28 and minimize the stress concentrations at the edges of protrusion 40. The oval shape of protrusion 40 eliminates sharp corners about the periphery thereof and thereby decreases the stress concentrations at the edges of protrusion 40. The greater transverse cross-sectional area at the midpoint of protrusion 40 is positioned at a critical area of femoral stem 20 (i.e., a high stress area where fatigue failure is likely to occur). The critical area of femoral stem 20 will vary depending upon whether femoral stem is implanted in a right or a left femur. The relatively wide midpoint of protrusion 40 allows femoral stem 20 to accommodate both right and left femur implantations as well as slight rotations of the femoral stem during implantation. Advantageously, protrusion 40 is positioned on the medial side of femoral stem 20 so that protrusion 40 is loaded in compression. In this way, the detrimental effects of stress risers in protrusion 40 are effectively negated.

[0014] Femoral stem 20 is, e.g., formed of a cobalt-chromium alloy. However, femoral stem 20 may be constructed of other bio-compatible metals or alloys, such as titanium. Similarly, porous coating 28 comprises, e.g., a beaded coating formed from a cobalt-chromium alloy, although various other porous coatings may be utilized in conjunction with the teachings of the present invention. The generally oval shape of protrusion 40 allows for maximum application of the porous outer surface while providing sufficient material to adequately increase the transverse cross-sectional moment of inertia of femoral stem 20. As stated above, the midpoint of protrusion 40 comprises the portion of protrusion 40 having the greatest transverse cross-sectional area. The midpoint of protrusion 40 is positioned at medial curve tangency 34. Medial curve tangency 34 comprises the portion of medial curve 32 tangent to cylindrical femoral shaft 36. In other words, medial curve tangency 34 is located at the point where medial curve 32 ends and cylindrical femoral shaft 36 begins. In one exemplary femoral stem, medial curve tangency 34 comprises a critical area of the femoral stem (i.e., a high stress area where fatigue failure is likely to occur).

[0015] Less protrusion material is required toward the proximal end of the stem because the transverse cross-sectional area of the stem in transition section 30 is larger than the transverse cross-sectional area of femoral shaft 36, while less material is needed toward the distal end of the stem since this end of femoral stem 20 will be solidly fixed in the femur. With this in mind, the transverse cross-sectional area of protrusion 40 of the exemplary embodiment illustrated in Figures 1, 2, and 8 generally decreases from the midpoint thereof to the proximal and distal ends thereof to allow for maximum application of the porous coating. In one exemplary embodiment, protrusion 40 extends from it's midpoint approximately 2.5 centimeters (1 inch) into transition section 30 and approximately 2.5 centimeters (1 inch) into femoral shaft 36.

[0016] Figures 3 and 9 illustrate femoral stem 20a in accordance with a second embodiment of the present

invention. The several embodiments of the present invention include similar components to the embodiment illustrated in Figures 1, 2, and 8. These similar components are denoted with a reference numeral having a letter appended thereto. For the sake of brevity, these similar components will not all be discussed in conjunction with the various alternative embodiments disclosed herein. Femoral stem 20a includes lateral protrusion 42 of similar shape to medial protrusion 40 illustrated in Figure 1. Lateral protrusion 42 is positioned on the lateral side of femoral stem 20a with the midpoint thereof generally lying opposite medial curve tangency 34 of femoral stem 20. Various placements of the protrusions of the current invention may be utilized to increase the cross-sectional moment of inertia of the femoral stem and therefore increase the strength of a femoral stem. Furthermore, plural protrusions may be utilized to further increase the strength of a femoral component in accordance with the present invention. For example, medial protrusion 40 (Figure 1) may be used in conjunction with lateral protrusion 42 (Figures 3) to form a femoral stem in accordance with the present invention.

[0017] Figures 4-6 illustrate a third embodiment of the present invention having medial rib 44 and lateral rib 46. As illustrated in Figure 6, medial rib 44 and lateral rib 46 extend from substrate 26b and are flush with porous coating 28b. Ribs 44, 46 run substantially the length of femoral stem 20b and include end points which gradually taper to transition into substrate 26b. The smooth transitions provided by the tapering of the end points of ribs 44, 46 function to decrease stress risers therein. As illustrated in Figure 4, medial rib 44 generally runs from distal end 50b to the distal side of flange 24b. Similarly, lateral rib 46 runs from distal end 50b to shoulder 23b. Although illustrated as running substantially the length of femoral stem 20b, ribs 44, 46 may be partial ribs running along only a portion of the length of femoral stem 20b. It is further contemplated that ribs 44, 46 could be of varying width, with the greatest transverse cross-sectional area (associated with the greatest width) being positioned at a critical area.

[0018] Figure 7 illustrates a cross-sectional view of femoral stem 20c having a single rib 45. Rib 45 may be either a medial or lateral rib as discussed above with respect to femoral stem 20b. Figure 7 is provided to illustrate a single rib configuration in accordance with the present invention, as opposed to the dual rib configuration of Figures 4-6.

[0019] Figure 10 illustrates femoral stem 20d having helical rib 48. Helical rib 48 includes a proximal end adjacent the distal side of flange 50d and a distal end adjacent distal end 50d of femoral stem 20d. The proximal end of helical rib 48 is rotated 90° from the distal end of helical rib 48. Helical rib 48 will have particular applicability to longer femoral stems which experience substantial bending in the anterior-posterior plane of the distal portions thereof. The helical arrangement of rib 48 allows for rib placement in both the medial-lateral plane and the anterior-posterior plane of femoral stem 20d, with the anterior-posterior placement of rib 48 advantageously occurring in the distal portion of the femoral stem.

[0020] While described above with respect to a femoral stem having a porous coating, the ribs of the current invention may be utilized with a femoral stem absent such a porous outer coating. In such applications, the protrusions of the present invention will extend outwardly from the external surface of the femoral stem. In such situations, the height of the ribs will be sized so that the protrusion will be covered by the cement mantle formed by the bone cement utilized to implant the femoral stem.

[0021] While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

Claims

1. A prosthetic stem for implantation in a bone comprising:

   a neck connected to a shaft, said neck and said shaft forming an obtuse angle;
   a porous substance protruding outwardly from a substrate of the prosthetic stem; and
   a substantially nonporous protrusion protruding outwardly from said substrate and being substantially flush with said porous substance.

2. The prosthetic stem of Claim 1, wherein said porous substance encircles a periphery of said protrusion.

3. The prosthetic stem of Claim 1, wherein said porous substance substantially covers the prosthetic stem.

4. The prosthetic stem of Claim 1, wherein said substrate has a substrate porosity and said substantially nonporous protrusion has a protrusion porosity, and wherein said substrate porosity substantially equals said protrusion porosity.

5. The prosthetic stem of Claim 1, further comprising:

   a transition section intermediate said neck and said shaft, said transition section having a transverse cross-sectional area larger than a transverse cross sectional area of said shaft, said substantially nonporous protrusion extending from said shaft into said transition section.

6. The prosthetic stem of Claim 5, wherein said substantially nonporous protrusion extends generally from a midpoint thereof about 2.5 centimeters (1 inch) into said transition section and about 2.5 centimeters (1 inch) into said shaft.

7. The prosthetic stem of Claim 6, wherein said substantially nonporous protrusion has a proximal end positioned on said transition section and a distal end positioned on said shaft, said substantially nonporous protrusion having decreasing transverse cross-sectional areas from said midpoint to each of said proximal and said distal ends.

8. The prosthetic stem of Claim 1, wherein said substantially nonporous protrusion comprises a rib extending substantially the entire length of the prosthetic stem.

9. The prosthetic stem of Claim 8, wherein said rib is generally helical, with a distal end thereof being rotated ninety degrees from a proximal end thereof.

10. A prosthetic hip stem for implantation in a femur comprising:

    a neck connected to a shaft, said neck extending from a medial side of said hip stem, said neck and said shaft forming an obtuse angle;
    a porous substance protruding outwardly from a substrate of the prosthetic hip stem; and
    a first substantially nonporous protrusion protruding outwardly from said substrate and being substantially flush with said porous substance.

11. The prosthetic hip stem of Claim 10, wherein said porous substance substantially covers the prosthetic stem.

12. The prosthetic hip system of Claim 10, wherein said substrate has a substrate porosity and said first substantially nonporous protrusion has a protrusion porosity, and wherein said substrate porosity substantially equals said protrusion porosity.

13. The prosthetic hip stem of Claim 10 herein said first substantially nonporous protrusion is positioned on said medial side of said hip stem.

14. The prosthetic hip stem of Claim 10 wherein said first substantially nonporous protrusion is positioned on a lateral side of said hip stem.

15. The prosthetic hip stem of Claim 13, further comprising a second substantially nonporous protrusion protruding outwardly from said substrate and being substantially flush with said porous substance, said second substantially nonporous protrusion positioned on a lateral side of said hip stem.

16. The prosthetic hip stem of Claim 15, further comprising:

    a transition section intermediate said neck and said shaft, said transition section having a transverse cross-sectional area larger than a transverse cross sectional area of said shaft, both said first and said second substantially nonporous protrusions extending from said shaft into said transition section, both said first and said second substantially nonporous protrusions extending generally from a midpoint thereof about 2.5 centimeters (1 inch) into said transition section and about 2.5 centimeters (1 inch) into said shaft.

17. The prosthetic hip stem of Claim 10, further comprising:

    a transition section intermediate said neck and said shaft, said transition section having a transverse cross-sectional area larger than a transverse cross sectional area of said shaft, said first substantially nonporous protrusion having a proximal end positioned on said transition section and a distal end positioned on said shaft, said first substantially nonporous protrusion having decreasing transverse cross-sectional areas from a midpoint thereof to each of said proximal and said distal ends.

18. The prosthetic hip stem of Claim 13, wherein said first substantially nonporous protrusion comprises a first rib extending substantially the entire length of the prosthetic stem.

19. The prosthetic hip stem of Claim 15, wherein said first and said second substantially nonporous protrusions respectively comprise a first rib and a second rib, both said first and said second ribs extending substantially the entire length of the prosthetic stem.

20. A prosthetic hip stem for implantation in a femur utilizing bone cement to form a mantle about a portion of the hip stem inserted into a canal in a femur, wherein the hip stem comprises:

    a neck connected to a shaft, said neck extending from a medial side of said hip stem, said neck and said shaft forming an obtuse angle;
    a transition section intermediate said neck and said shaft, said transition section having a transverse cross-sectional area larger than a transverse cross sectional area of said shaft; and

a first protrusion protruding outwardly from an external surface of the prosthetic hip stem, said first protrusion having a height whereby said first protrusion is covered by the mantle.

21. The prosthetic hip stem of Claim 20, wherein said first protrusion is positioned on said medial side of said hip stem.

22. The prosthetic hip stem of Claim 21, further comprising a second protrusion protruding outwardly from said external surface of the prosthetic hip stem, said second protrusion having a height whereby said second protrusion is covered by the mantle, said second protrusion positioned on a lateral side of said hip stem.

23. The prosthetic hip stem of Claim 20, wherein said first protrusion includes a proximal end positioned on said transition section and a distal end positioned on said shaft, said first protrusion having decreasing transverse cross-sectional areas from a midpoint thereof to each of said proximal and said distal ends.

24. The prosthetic hip stem of Claim 21, wherein said first protrusion comprises a first rib extending substantially the entire length of the prosthetic stem.

25. The prosthetic hip stem of Claim 22, wherein said first and said second substantially nonporous protrusions respectfully comprise a first rib and a second rib, both said first and said second ribs extending substantially the entire length of the prosthetic stem.

26. The prosthetic hip stem of Claim 24, wherein said first rib is generally helical, with a distal end thereof being rotated ninety degrees from a proximal end thereof.

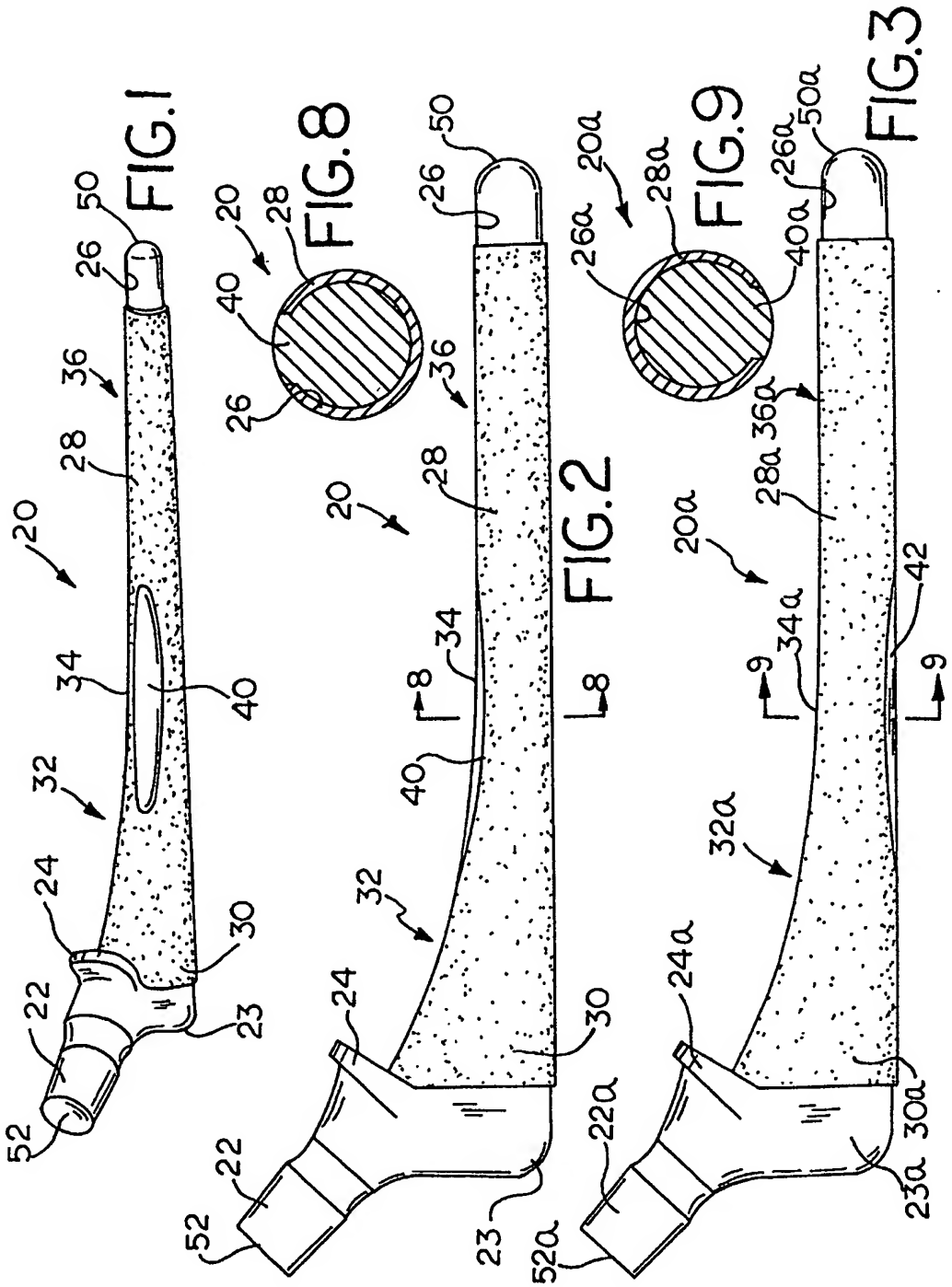
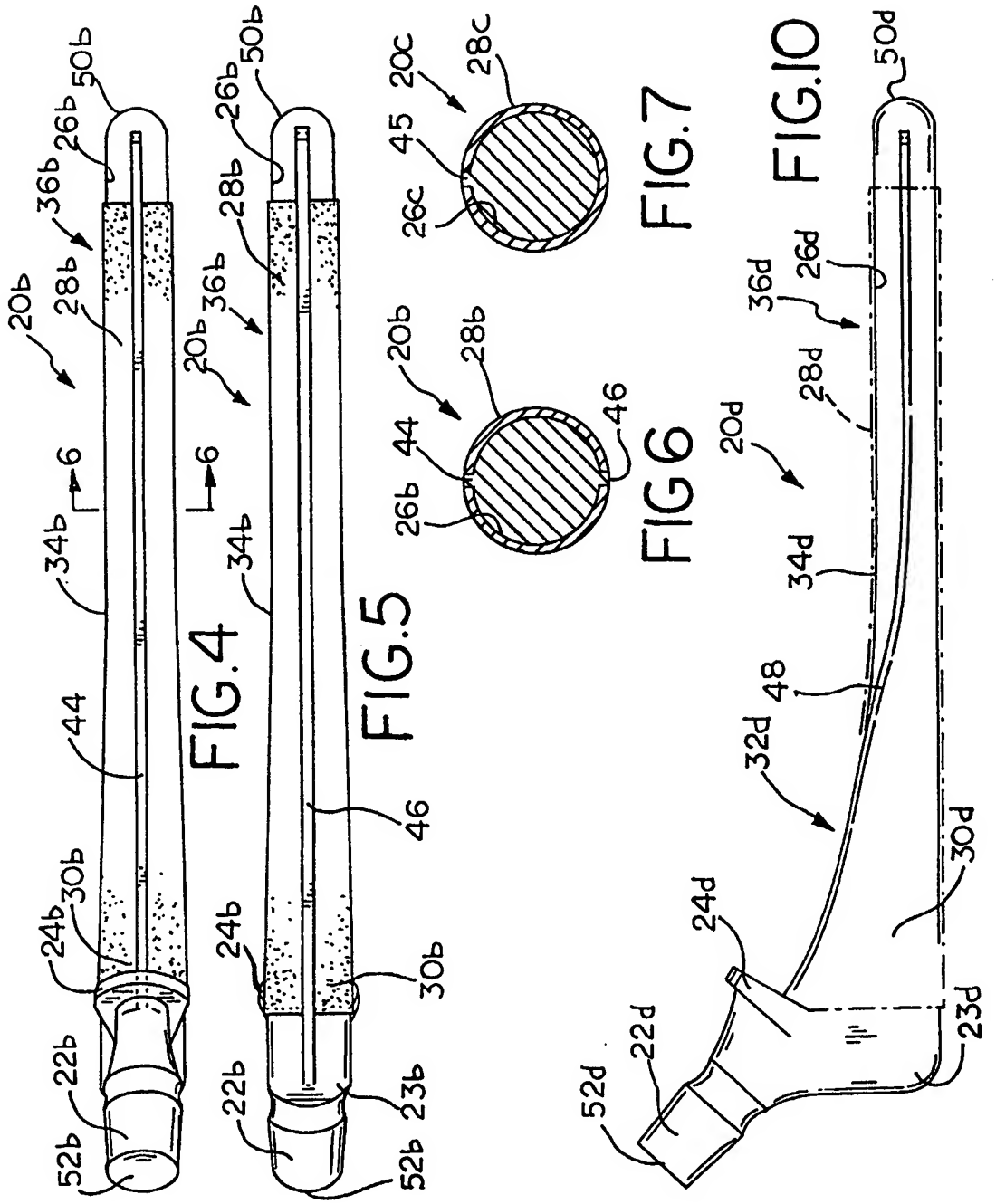


FIG.1
FIG.8
FIG.2
FIG.9
FIG.3
20
20a
22
22a
23
23a
24
24a
26
26a
28
28a
30
30a
32
32a
34
34a
36
36a
40
40a
42
50
50a
52
52a
8
9


20b
28b
36b
26b
50b
6
34b
44
24b
30b
22b
52b
FIG.4
20b
28b
36b
26b
50b
6
34b
46
24b
30b
22b
23b
52b
FIG.5
20c
28c
45
26c
20b
28b
44
46
26b
FIG6
FIG.7
50d
26d
36d
28d
20d
34d
48
32d
24d
30d
22d
23d
52d
FIG.10